REMARKS

Reconsideration and allowance of the subject application in view of the foregoing amendments and the following remarks is respectfully requested.

Claims 1-3 have been cancelled and claims 4-10 have been added.

Claims 1 and 2 are rejected under 35 U.S.C. 102(b) as being anticipated by Jones et al., U.S. 4,987,563. In response, claims 1 and 2 have been cancelled and replaced with new claims 4-10.

New independent claim 4 recites that the antenna according to the invention comprises at least two zones:

(1) A main zone stretching from the center of the antenna in which the sensors are distributed with a pitch d, whose value is defined so as to avoid the appearance in the reception diagram of the antenna of grating lobes with a high gain level.

(2) At least one other zone located at one end of the antenna in which the sensors are distributed with a pitch d' whose value, smaller than that of d, is defined so as to obtain the desired precision for the self-calibration.

Jones et al. teaches how to make an antenna working in near field conditions and able to focus on points located at different distances. For this purpose, the antenna disclosed comprises sensors of different sizes on which is applied a particular phase law. Thus, the size of one particular sensor is dependent on its position in the antenna. Sine the size is different from one sensor to the other, the pitch according to which the sensors are located varies and creates different zones with different values of pitch. Nevertheless, the value of the pitch is not here defined by the condition to obtain a receiving channel without important grating lobes, but rather by the condition that allows the antenna to focus correctly at minimum range in spite of the phase shifts introduced along the antenna by the reception in near field conditions of the signal reflected by the sea bottom. The value of the array spacing resulting from these conditions is different; they are set to the value of pitches d and d'. Moreover, such a spacing is incompatible with the realization of a synthetic antenna. Consequently, applying the conditions of spacing

disclosed in Jones et al. does not practically allow the antenna of the invention to be define.

In Jones et al., the array spacing is made variable so that along one element the variation of the phase correction required for focusing the array at some minimum range R_{min} does not exceed some limit $\delta.\phi$ (see claim 7, points C and D). For instance, $\delta.\phi$ could take the value 180° .($\delta.\phi = 180°$) corresponding to a propagation length differential equal to $\lambda/2$, λ being the wavelength, as depicted in Fig. 20 or else the value for 90° ($\delta\phi = 90°$) the center element (Fig. 20) .

In the present invention, the array spacing (pitch) in the main central zone of the array is determined by the width $\Delta\Theta$ along the bearing axis of the transmit sector. Because the best resolution achievable by a synthetic aperture sonar is a proportional inverse to $\Delta\Theta$, $\Delta\Theta$ is larger in a synthetic aperture sonar than in a conventional sidescan sonar. This is the reason why in a synthetic aperture sonar, as considered in the present invention, the spacing determined by $\Delta\Theta$, on the order of $0.7.\lambda/\Delta.\Theta$. is smaller than the spacing fixed by the focusing-related constraint and determined by the minimum range in a sidescan sonar without synthetic aperture, as considered in Jones et al.

Example:

We assume $R_{min} = 10$ m, a rather low figure, much smaller than in the example given in Jones et al., column 5, line 55, where $R_{min} = 350$ feet ≈ 100 m. Hence the spacing constraint considered in Jones et al. is much tighter in such an example.

For a straight line array, the length $2A$ of the center element Jones et al., Fig. 16, formula at the top of column 7 with $x = \lambda/4$) is given by:

$$\frac{\lambda}{4} = \frac{A^2}{2R_{min}} \qquad (1)$$

Hence $2A = (2\lambda R_{min})^{1/2}$ that is equal to ̃3 meter at frequency $f = 300$ kHz, a typical value for a shallow water sonar corresponding to $\lambda = 5.10^{-3}$ m. The length of the extreme elements can be derived from the following relation (see Fig. 20 in Jones et al.):

$$\delta\left[\frac{A^2}{2R_{min}}\right]_{A=L/2} = \frac{\lambda}{2} \qquad (2)$$

where □ is the finite difference operator and L is the array length. Then combining Jones et al. and the present invention we obtain:

$$\delta\left[\frac{A^2}{2R_{min}}\right]_{A=L/2} \approx \frac{L}{2R_{min}}\delta A.$$

Hence the length of both end elements is

$$\delta A \approx R_{min}\frac{\lambda}{L} \quad (3)$$

For the typical value L = 1 m, and the previous values for R_{min} and λ, the length of the end elements is 5 cm. Hence in the array designed according to Jones et al., the length of the elements is varying between 30 cm at the center to 5 cm at the ends. Because the width of the directivity pattern of an element of length l is λ/l expressed in radian, this sonar is not suited for beamforming in a sector wider than 1°.

Now we look to an array designed according to Jones et al. with the same length and frequency. Then the constraint is relative to the spacing between elements rather than to the lengths of the elements. This is because the constraint is related to a desired level of the grating lobes for the main part of the array and to the accuracy of a space interpolation for at least one end part. We have here only two values of spacing. One for the main part of the array, which is given by the following relation:

$$d \approx 0.7\frac{\lambda}{\Delta\theta}, \qquad (4)$$

and another one available for at least one end part which satisfies the following relation:

$$d' \leq \frac{d}{1.5} \tag{5}$$

The transmit sector width $\Delta\Theta$ for a synthetic aperture sonar is usually between 0.1 and 0.2 rd. Let us assume $\Delta\Theta = 0.1$ rd which corresponds to the less constraining value for the array spacing. In such a case we have $d = 3.5$ cm and $d' \leq 2.3$ cm. So d and d' are respectively nine times less and two times less than the spacing defined by the previous design according to Jones et al.

Then, according to the present invention, the best achievable resolution up to the maximum range R_{max}, is $\lambda/(2. \Delta\Theta.) = 5\lambda$, equal to 2.5 cm in our example. The maximum range is limited by the minimum acceptable grazing angle, about 6°, to 10 times the altitude H of the sonar over the bottom. We have $H \leq R_{min}$, hence $R_{max} \leq 100$ m. On the other hand, the previous sonar, not designed for synthetic aperture processing, achieves a resolution equal to λ/L at range R, equal to 5 cm at range $R_{min} = 10$ m and equal to 50 cm at range $R_{max} = 100$ m.

So even for a very low value of R_{min}, the spacing constraint in Jones et al., suited to real aperture beamforming in a very narrow sector, is much weaker than the constraint in the present invention related to the transmit sector width and suited to synthetic aperture processing. In most practical cases, the difference between both designs will be still larger.

For instance, the following values are considered in Jones et al. (column 5, $R_{min} = 350$ feet, $R_{max} = 1400$ feet, $\lambda = \frac{7}{8}$ inch, $L = 30$ feet). Then the length $2A$ of the center element, as determined from previous equation (1) would be about 7 feet, and the length δA of both ends elements determined from equation (2) would be about 0.9 feet. For a synthetic aperture sonar designed according to the present invention with $\Delta\Theta = 0.2$rd, the spacing value would be equal to three inches in the main part of the array, as given by equation (3), and less or equal to two inches at the end.

However, this case is also an extreme case because of the very unusual length of the array. For $L = 10$ feet, which is already a rather large value for a sonar operating at $f = 70$ kHz, the previous values of the elements spacing according to the present invention and the value of the center element length according to Jones et al. remains unchanged but the length of both end elements according to Jones et al. is 2.5 feet, that is about 15 times the maximum spacing value in a end part of the array according to the present invention. This example is submitted to show

that the conditions of spacing disclosed in Jones et al. does not practically allow the antenna of the present invention to be defined.

This document discloses a sparse array antenna which has nothing to do with the object of the present application, which is a naturally non-sparse antenna. Further, the specific characteristics about the values of pitches d and d' are not disclosed in Jones et al. Accordingly, Jones et al. does not anticipated new claims 4-10 and the rejection should be withdrawn.

Claims 1 and 3 are rejected under 35 U.S.C. 102(b) as being anticipated by Gilmour, U.S. 4,987,563.

This documents discloses a sparse array antenna which has nothing to do with the object of the present invention which is a naturally non-sparse antenna. Further, the specific characteristics about the values of pitches of d and d' are not discloses in Gilmour. Accordingly, Gilmour does not anticipate new claims 4-10 and the rejection should be withdrawn.

All objections and rejections having been addressed, it is respectfully submitted that the present application should be in condition for allowance and a Notice to that effect is earnestly solicited.

To the extent necessary, a petition for an extension of time under 37 C.F.R. 1.136 is hereby made. Please charge any shortage in fees due in connection with the filing of this paper, including extension of time fees, to Deposit Account 07-1337 and please credit any excess fees to such deposit account.

Respectfully submitted,

LOWE HAUPTMAN & BERNER, LLP

Kenneth M. Berner

Kenneth M. Berner
Registration No. 37,093

Customer Number: 22429
1700 Diagonal Road, Suite 300
Alexandria, Virginia 22314
(703) 684-1111
(703) 518-5499 Facsimile
Date: August 21, 2006
KMB/jd